

From One Finite Operation to a Self-Indexing Mathematical World: Functional Completeness, Derived Meet, and Theory-Preserving Ontogenesis

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Can a mathematical world be generated from one finite operation without smuggling its final structure into the starting assumptions? This paper presents a constructive answer through a three-element binary seed whose term clone is functionally complete, whose derived terms expose a two-element meet algebra, and whose selected free construction yields a seven-object self-indexing world. The seed first generates every unary operation and satisfies the finite criterion for full positive-arity functional completeness. Explicit bridge terms then recover a retraction and a meet operation on a two-state image. From that derived algebra, the nonempty free meet-semilattice on three indexed generators appears as the punctured cube B^A minus the top element, equivalently as the seven nonempty subsets of a three-element index set. The construction separates theorem from policy: the seed proves expressive completeness and supports the bridge, while the choice of free world is stated openly rather than disguised as inevitability. Exhaustive computation, relabeling naturality, frozen certificates, and independent reconstruction make the result reproducible. The resulting architecture offers a terse model of theory-preserving ontogenesis: operation, term language, derived structure, indexed world, and certified reconstruction.

Keywords: theory-preserving ontogenesis, self-indexing mathematical world, finite universal algebra, functional completeness, Stupecki criterion, term clone, binary operation, derived meet-semilattice, free semilattice, punctured Boolean cube, mathematical object formation, automated theorem discovery, certified computation, algebraic abiogenesis, reproducible mathematics.

Code: <https://github.com/DougYouvan/theory-preserving-ontogenesis-v1.1.1-self-indexing-seed->

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1. The Ontogenesis Problem

Mathematics is usually developed from named objects and stated axioms. Groups, lattices, categories, and spaces appear as already formed domains. Their internal consequences are then derived. This method is powerful, but it leaves a prior question unanswered: how can a mathematical world arise before its objects and laws have been named?

The present construction reverses the usual order. It begins with one anonymous binary operation w on a three-element set A . No lattice, order, identity element, or familiar algebraic interpretation is assumed. The seed is judged only by the operations generated from it through projections and composition.

The developmental sequence is:

$$w \rightarrow \text{Clo}(w) \rightarrow (r, m) \rightarrow \Omega$$

Here:

$\text{Clo}(w)$ is the positive-arity term clone generated by w .

r is a derived retraction from A onto a two-element image B .

m is a derived meet operation on B .

Ω is a selected finite world constructed from B and indexed by A .

The first transition asks what the seed can express. The second identifies explicit terms that expose a simpler internal algebra. The third constructs a new object-world from that derived algebra.

These transitions do not have the same logical status. The clone $\text{Clo}(w)$ is determined by the seed. The operations r and m are explicit witnesses inside that clone. The world Ω is then selected by a stated construction policy. The seed supports this world, but it does not uniquely force it.

This separation prevents emergence from becoming concealed specification. A structure may be derivable without being canonical. A bridge may be explicit without being unique. A free construction may be natural without being logically inevitable.

The selected world is the nonempty free meet-semilattice on three indexed generators. It has seven elements and admits three equivalent descriptions:

$$\Omega \cong P(A) - \{\emptyset\}$$

$$\Omega \cong F^+ \wedge(A)$$

$$\Omega \cong B^A - \{T^A\}$$

In the subset representation, the objects are the seven nonempty subsets of A . Their meet is union when the order is reverse inclusion. In the function representation, the same objects are the nonconstant-top maps from A into the derived two-element meet algebra B .

The world is self-indexing because the original carrier A returns as the generator index set. Its role changes. Initially, A is the domain on which the seed operates. Later, its elements label the independent coordinates of the constructed world.

The construction therefore preserves an index while changing its mathematical interpretation:

operational states $\rightarrow$ generator labels

Theory-preserving ontogenesis is not creation from literal nothing. It is the controlled formation of mathematics from a minimal explicit seed. Every stage must expose its terms, maps, assumptions, and construction choices.

The aim is a compact chain of certified formation:

one operation $\rightarrow$ complete expression language $\rightarrow$ derived meet $\rightarrow$ seven-object world

Nothing essential is hidden. Nothing chosen is presented as forced.

2. The Three-Element Seed

Let the carrier be

$$A = \{0, 1, 2\}.$$

Define one binary operation $w: A \times A \rightarrow A$ by

$$w = 201/122/010$$

or equivalently:

	0	1	2
0	2	0	1
1	1	2	2
2	0	1	0

Rows specify the first argument and columns the second. Thus $w(0,0) = 2$, $w(0,1) = 0$, and $w(2,2) = 0$.

The symbols 0, 1, and 2 are labels only. No numerical order, arithmetic, topology, lattice structure, or interpretation is assigned to them. Relabeling the carrier by any permutation produces an equivalent seed.

The initial language contains only variables and w . Terms are generated recursively:

variable

$w(\text{term}, \text{term})$

No constants or auxiliary operations are supplied. Every derived operation must arise through repeated substitution into w . Two terms are identified when they define the same finite function on A .

The resulting positive-arity term language is therefore generated by the single rule

$$(f, g) \mapsto w(f, g),$$

where w is applied pointwise to previously generated functions.

For unary terms, the cumulative closure counts by height are

$$1 \rightarrow 2 \rightarrow 5 \rightarrow 21 \rightarrow 27.$$

There are exactly 27 unary functions $A \rightarrow A$, so the unary closure is complete.

For binary terms, the cumulative counts are

$2 \rightarrow 6 \rightarrow 38 \rightarrow 1,256 \rightarrow 19,681 \rightarrow 19,683$.

There are exactly

$3^9 = 19,683$

binary functions $A^2 \rightarrow A$. The seed therefore generates every binary operation on its carrier.

The final two binary functions absent at height four appear at height five. Their appearance is recorded by explicit parent terms, making completion a finite certificate rather than an inference from numerical saturation.

The seed is also surjective. Every element of A occurs as an output of w . Both inputs are essential: changing either argument can change the output while the other remains fixed. Thus w is neither a disguised unary map nor a projection.

Its table does not visibly present the structure later extracted from it. It is not commutative, associative, idempotent, or immediately recognizable as a standard algebraic operation. The derived order appears only after suitable terms have been formed.

The starting datum is therefore minimal in kind, though not claimed to be globally minimal in size:

one finite carrier

one binary table

projection

composition

Everything that follows must be expressed inside the language generated by this seed.

3. Functional Completeness

The seed does more than generate many operations. It generates every positive-arity finitary operation on A .

Let $\text{Clo}(w)$ denote the clone generated by w and the projections. For each arity $n \geq 1$, $\text{Clo}(w)$ contains operations $A^n \rightarrow A$ obtained by finite term composition.

The unary audit is exhaustive. Since $|A| = 3$, the number of unary operations is

$$3^3 = 27.$$

All 27 occur in $\text{Clo}(w)$. In particular, the clone contains:

all three constant unary maps

all six permutations of A

all eighteen remaining unary maps

The binary audit is also exhaustive. Since $|A^2| = 9$, the number of binary operations is

$$3^9 = 19,683.$$

All 19,683 are generated. Thus the seed can directly express every binary table on the carrier.

The all-arity conclusion follows from a finite functional-completeness criterion. For a finite set A with at least three elements, a clone is full when it contains every unary operation and contains a surjective operation depending essentially on at least two variables.

The operation w satisfies these conditions.

First, every unary map $A \rightarrow A$ lies in $\text{Clo}(w)$.

Second, w is surjective:

$$\text{Im}(w) = A.$$

Third, both arguments are essential. There exist fixed values for which changing the first input changes the output, and fixed values for which changing the second input changes the output.

Therefore,

$$\text{Clo}(w) = \mathcal{O}_A,$$

where $\mathcal{O}_A$ is the full clone of all positive-arity operations on A.

Equivalently, for every $n \geq 1$ and every function

$$f: A^n \rightarrow A,$$

there exists a term t built only from w and variables such that

$$t^A = f.$$

This result gives the seed universal expressive power over its finite carrier. Every finite operation on A can be represented internally in the term language of w .

Functional completeness does not imply that every representation is short. Nor does it identify a privileged interpretation of the seed. It guarantees only expressibility.

This distinction matters. The seed contains every possible algebraic behavior on A , including groups, semilattices, Boolean fragments, selectors, constants, permutations, and arbitrary lookup tables. A later construction must therefore identify a useful internal structure by explicit witness terms rather than by mere existence.

The complete clone acts as a universal finite language. Within it, one may search for operations satisfying chosen identities. In the present development, the target is a two-state retract carrying a meet operation.

Thus the first major transition is established:

one anonymous binary operation

→ every positive-arity operation on A

The seed is not merely generative. On its carrier, it is expressively complete.

4. Retraction and Derived Meet

Functional completeness guarantees that the seed can express every operation on A .

Ontogenesis requires more than expressibility: it requires an explicit bridge from the three-state language to a simpler internal algebra.

Define the unary term

$$r(x) = w(w(x,x), w(x,x)).$$

Direct evaluation gives

$$x \quad 0 \ 1 \ 2$$

$$r(x) \quad 0 \ 0 \ 2$$

Hence

$$r(r(x)) = r(x)$$

for every $x \in A$. Therefore r is an idempotent retraction with image

$$B = r(A) = \{0, 2\}.$$

The element 1 is not deleted arbitrarily. It is identified with 0 by an operation generated internally from w . The seed therefore contains a derived two-state core.

Now define the binary term

$$m(x,y) = w(w(x,x), w(y,x)).$$

Restricted to B, its table is

0 2		
0		0 0
2		0 2

Thus

$$m(0,0) = 0$$

$$m(0,2) = 0$$

$$m(2,0) = 0$$

$$m(2,2) = 2.$$

On B, the operation m is closed, idempotent, commutative, and associative:

$$m(x,x) = x$$

$$m(x,y) = m(y,x)$$

$$m(m(x,y),z) = m(x,m(y,z)).$$

The element 0 is absorbing:

$$m(0,x) = 0.$$

The element 2 is an identity:

$$m(2,x) = x.$$

Therefore (B,m) is the two-element meet-semilattice with bottom 0 and top 2.

Its induced order is

$$0 \leq 2.$$

Equivalently,

$x \leq y$ exactly when $m(x,y) = x$.

The bridge from the seed to the meet core can now be written compactly:

$(A,w) \vdash r$

$r(A) = B$

$(A,w) \vdash m$

$(B,m) \cong (\{0,1\}, \wedge)$

The symbol $\vdash$ records term definability. Both r and m are expressions in the original language; no external operation has been added.

The retraction and meet play different roles. The map r selects the stable two-state image. The operation m equips that image with order. Together they convert the anonymous seed into a Boolean-valued observational algebra.

For every $a \in A$ and every state $x \in B$, the value x can now be interpreted as one of two responses:

0 = present, selected, or supported

2 = absent, unselected, or top

This interpretation is conventional, but the algebra beneath it is not. The absorbing and identity elements are derived from the operation table.

The pair (r,m) is an explicit witness, not a uniqueness claim. Because w generates the full clone, many other retractions and derived operations exist. The present pair is selected because it is short, transparent, and sufficient for the next construction.

The second major transition is therefore:

complete three-state term language

→ derived two-state meet algebra

The seed has not yet produced the seven-object world. It has produced the algebra from which that world can be freely constructed.

5. The Seven-Object Self-Indexing World

Let $A = \{0,1,2\}$ be the original carrier and let $B = \{0,2\}$ be the derived two-element meet algebra.

The next step is not forced by the seed alone. It is a declared construction policy:

Construct the nonempty free meet-semilattice generated by the elements of A .

Denote this world by Ω . Then

$$\Omega = F^+\wedge(A).$$

Because A has three elements, Ω contains one object for each nonempty finite meet of distinct generators. Hence

$$|\Omega| = 2^3 - 1 = 7.$$

Using generator symbols g_0 , g_1 , and g_2 , the seven objects are

g_0

g_1

g_2

$g_0 \wedge g_1$

$g_0 \wedge g_2$

$g_1 \wedge g_2$

$g_0 \wedge g_1 \wedge g_2$.

Idempotence, commutativity, and associativity remove repetition and order. No empty meet is included. Thus there is no freely adjoined top element.

The same world has a subset representation:

$$\Omega \cong P(A) - \{\emptyset\}.$$

Each nonempty subset $S \subseteq A$ represents the meet of the generators indexed by S . Under this correspondence,

$$S \wedge T = S \cup T.$$

The order is reverse inclusion:

$S \leq T$ exactly when $S \supseteq T$.

Thus larger supports represent lower elements. The three singleton subsets are the free generators, while A itself is the least element.

A third representation uses the derived algebra B . For each nonempty subset $S \subseteq A$, define a function $\chi_S: A \rightarrow B$ by

$$\chi_S(a) = 0 \text{ when } a \in S,$$

$$\chi_S(a) = 2 \text{ when } a \notin S.$$

The excluded empty subset would produce the constant-top function. Therefore

$$\Omega \cong B^A - \{\top^A\}.$$

Pointwise meet corresponds exactly to union of supports. For all nonempty S and T ,

$$\chi_S \wedge \chi_T = \chi_{S \cup T}.$$

The seven objects may therefore be displayed as the punctured three-dimensional binary cube. The full cube B^A has eight vertices. Removing the constant-top vertex leaves seven.

This representation explains the phrase self-indexing. The original set A first appears as the carrier of the seed operation. It later reappears as the coordinate set of B^A and as the generator set of $F^+ \wedge(A)$.

The carrier is reused, but its role changes:

A as operational states

becomes

A as generator indices.

The resulting world is free. For every meet-semilattice L and every map $f: A \rightarrow L$, there exists a unique meet-homomorphism

$$\hat{f}: \Omega \rightarrow L$$

satisfying

$$\hat{f}(\{a\}) = f(a)$$

for each $a \in A$.

Explicitly,

$$\hat{f}(S) = \bigwedge_{a \in S} f(a).$$

This universal property defines Ω independently of the subset and cube representations. The seven-element structure is therefore not merely an enumerated example. It is the canonical nonempty free meet-semilattice on three named generators.

The third transition is now complete:

derived two-state meet algebra

→ nonempty free meet world indexed by the original carrier.

The seed supplies expressive power. The bridge supplies the meet algebra. The declared policy supplies the free world.

6. Reconstruction by Three Binary Views

The seven-object world Ω can be reconstructed from evaluations into the derived two-element meet algebra B .

For each index $a \in A$, define the coordinate view

$$v_a: \Omega \rightarrow B$$

by

$$v_a(S) = 0 \text{ when } a \in S,$$

$$v_a(S) = 2 \text{ when } a \notin S.$$

Each view records one binary distinction: whether the generator indexed by a occurs in the support of the object.

Because meet in Ω is union of supports,

$$v_a(S \wedge T) = v_a(S) \wedge v_a(T).$$

Thus every coordinate view is a meet-homomorphism.

Collect the three views into one map:

$$V: \Omega \rightarrow B^A$$

$$V(S) = (v_0(S), v_1(S), v_2(S)).$$

This map is injective. Distinct nonempty subsets differ at some index, and the corresponding coordinate detects that difference.

The image of V is exactly

$$B^A - \{T^A\}.$$

Hence

$$\Omega \cong B^A - \{T^A\}.$$

The world is therefore reconstructed without naming its seven objects individually. Each object is determined by its three binary responses.

For example:

$$\{0\} \mapsto (0,2,2)$$

$$\{1\} \mapsto (2,0,2)$$

$$\{2\} \mapsto (2,2,0)$$

$$\{0,1\} \mapsto (0,0,2)$$

$$\{0,2\} \mapsto (0,2,0)$$

$$\{1,2\} \mapsto (2,0,0)$$

$$\{0,1,2\} \mapsto (0,0,0).$$

No two coordinate views can reconstruct Ω injectively. Two binary views provide at most

$$2^2 = 4$$

distinct response patterns, while Ω has seven objects.

Three views provide

$$2^3 = 8$$

patterns, of which seven are used.

Therefore the minimum number of two-state meet-homomorphic coordinate views required for an injective product representation is three.

The lower bound is cardinal:

$$4 < 7.$$

The upper bound is constructive: the three coordinate views separate all objects.

Thus the reconstruction number of Ω relative to B is

$$3.$$

This number agrees with the number of free generators and with the size of the original carrier A.

The self-indexing relation is therefore exact:

three seed states

three free generators

three coordinate views

seven reconstructed objects.

The construction compresses the entire world into three binary observations. Objecthood is determined by a response profile, and equality is determined by agreement under all coordinate views:

$S = T$ exactly when $v_a(S) = v_a(T)$ for every $a \in A$.

The seven-object world is not stored as a list. It is recovered as the jointly separating image of three derived binary perspectives.

7. Relabeling Naturality and Computational Certification

A finite construction can appear correct only because its labels were chosen conveniently. The present result therefore includes a relabeling test.

Let σ be any permutation of A. Conjugate the seed by σ :

$$w\sigma(x,y) = \sigma(w(\sigma^{-1}(x), \sigma^{-1}(y))).$$

This operation is the same abstract seed written with different names for its three states.

The full construction is then repeated from the relabeled table. One recomputes:

the unary closure,

the binary closure,

the retraction,

the derived meet,

the two-element image,

the seven-object world,

and the coordinate reconstruction.

For every permutation σ , the resulting structure agrees with the original construction after transport of labels.

Since A has three elements, there are six permutations. All six pass the certificate.

This establishes a finite naturality statement:

relabel seed $\rightarrow$ rebuild bridge $\rightarrow$ rebuild world

agrees with

build world $\rightarrow$ relabel indices.

The test is stronger than permuting a finished output. It verifies that the developmental route itself commutes with relabeling.

The carrier labels therefore have no intrinsic meaning. The symbols 0, 1, and 2 are coordinates of presentation, not mathematical content.

The release also includes exhaustive finite certificates.

For unary operations, the closure contains all 27 maps $A \rightarrow A$.

For binary operations, the closure contains all 19,683 maps $A^2 \rightarrow A$.

The two final binary maps absent at height four are recovered at height five with explicit parent witnesses.

The bridge terms are evaluated directly on every required input.

The retraction certificate verifies:

$$r(r(x)) = r(x)$$

for all $x \in A$.

The derived meet certificate verifies closure, idempotence, commutativity, and associativity on B .

The world certificate verifies:

$$|\Omega| = 7,$$

closure under meet,

the subset representation,

the punctured-cube representation,
and separation by the three coordinate views.

The reconstruction certificate verifies both bounds:

two binary views are insufficient,
three coordinate views are sufficient.

The release artifacts are deterministic. Repeated executions reproduce the principal reports byte-for-byte. The same results hold under different hash seeds and under optimized Python execution.

The proof architecture therefore has three layers.

The first layer is exhaustive finite computation. It establishes exact closure counts, explicit tables, and identity checks.

The second layer is finite universal algebra. It converts the unary and seed properties into full positive-arity functional completeness.

The third layer is structural proof. It identifies the derived meet, the free semilattice, and the separating coordinate representation.

No single layer carries the entire result. Computation supplies exact witnesses. General theory extends finite observations to all positive arities. Universal properties explain why the seven-object world is the selected free construction rather than an accidental list of states.

Certification does not make the construction unique. It makes the stated construction inspectable.

The essential reproducibility claim is therefore:

the same seed, terms, and policy produce the same certified world.

This is the computational meaning of theory-preserving ontogenesis. Each transformation can be rerun, checked, and transported without dependence on hidden interpretation.

8. Theorem, Bridge, and Construction Policy

The construction contains three logically distinct components.

The theorem is what follows from the seed alone.

The bridge is an explicit family of derived terms.

The construction policy selects the mathematical world built from the derived algebra.

These components should not be collapsed.

From the seed w , one proves:

$\text{Clo}(w)$ is the full positive-arity clone on A .

This is a property of the operation itself. It does not depend on choosing the later semilattice interpretation.

Inside that complete language, one exhibits the terms r and m . They satisfy:

$$r(A) = B = \{0, 2\},$$

$$r \circ r = r,$$

and

(B, m) is a two-element meet-semilattice.

These terms form the bridge. Their existence is guaranteed abstractly by functional completeness, but the paper uses explicit short witnesses. The bridge is therefore constructive and auditable.

The bridge is not claimed to be unique. A functionally complete seed supports many retractions, many binary operations, and many internal algebraic interpretations. The selected pair is preferred because it is simple and leads directly to the desired world.

The final step introduces the policy:

$$\Omega = F^+ \wedge(A).$$

This policy chooses the nonempty free meet-semilattice generated by the original carrier.

Nothing in functional completeness alone forces this object. One could instead construct a Boolean algebra, a full free semilattice with top, a product algebra, a graph of derived operations, or another finite theory-bearing world.

The present policy is selected because it satisfies four constraints:

it uses only the derived meet algebra,

it reuses A as its index set,

it produces a finite nontrivial world,

and it admits exact reconstruction by binary coordinate views.

The full logical dependency is therefore:

w proves expressive completeness.

Explicit terms in w produce r and m.

The image B carries the derived meet.

A declared free-construction policy produces Ω .

This may be written tersely as:

$w \vdash \text{Clo}(w) = O_A$

$w \vdash r, m$

$r(A) = B$

$(B, m) \cong 2$

$\Omega := F^+ \wedge (A)$

$\Omega \cong B^A - \{T^A\}$.

The symbols $\vdash$ and $:=$ must not be confused.

The symbol $\vdash$ marks derivability.

The symbol $:=$ marks definition or construction choice.

This distinction is the central discipline of the paper.

Without it, a chosen ontology can be misrepresented as an inevitable consequence of the seed.

With it, every stage has a clear status:

proved,

witnessed,

or selected.

The result is therefore stronger than a demonstration that one operation can encode a seven-element structure. Encoding alone is cheap under functional completeness.

The substantive achievement is an explicit developmental chain whose dependencies remain visible:

seed $\rightarrow$ language $\rightarrow$ bridge $\rightarrow$ algebra $\rightarrow$ world $\rightarrow$ reconstruction.

The theory is preserved because each stage records how the next stage is obtained.

The ontogenesis is genuine because the final object-world is not inserted into the initial operation table as a named structure.

The result remains modest because it does not claim uniqueness, absolute minimality, or metaphysical necessity.

Its claim is exact:

one finite operation supports a complete internal language, a short derived meet bridge, and a reproducible self-indexing seven-object world.

9. Conclusion

This paper presents a complete finite ontogenesis:

one binary operation

→ a full positive-arity term clone

→ an explicit retraction

→ a derived two-element meet algebra

→ a seven-object free world

→ exact reconstruction by three binary views.

The construction begins with no named algebraic interpretation. Its first achievement is expressive completeness. The seed generates every positive-arity operation on its three-element carrier.

Expressive completeness alone is not ontogenesis. A complete language can represent many incompatible structures. The decisive step is therefore the explicit bridge:

$w \vdash r, m.$

The retraction r identifies a stable two-state image B . The operation m equips B with meet. This converts universal expressive power into a specific internal order structure.

The seven-object world is then introduced transparently by policy:

$\Omega := F^+ \wedge(A).$

It is simultaneously:

the nonempty free meet-semilattice on A ,

the set of nonempty subsets of A ,

and the punctured cube $B^A - \{\text{top}^A\}$.

Its objects are reconstructed by three coordinate homomorphisms into B . Three views are sufficient because they separate all seven elements. Two are impossible because four binary response patterns cannot distinguish seven objects.

The resulting compression is exact:

3 states $\rightarrow$ 2-state core $\rightarrow$ 3 views $\rightarrow$ 7 objects.

The construction is invariant under all relabelings of the seed carrier. Its calculations are exhaustive, its bridge terms are explicit, and its principal artifacts are reproducible.

The central methodological result is the separation of three claims:

the seed proves,

the bridge witnesses,

the policy selects.

This separation prevents a chosen world from being presented as a logically forced one. It also prevents functional completeness from being mistaken for structural explanation.

The seed does not uniquely determine the seven-object world. It supplies a complete language in which the required bridge can be written. The bridge does not uniquely determine the free construction. It supplies the algebra from which the chosen world can be built. The free construction does not erase these distinctions. It records them.

Theory-preserving ontogenesis is therefore not the generation of arbitrary complexity. It is the formation of new mathematical structure while preserving a complete account of derivation, interpretation, and choice.

The final result may be compressed to:

$w \vdash r, m$

$B = r(A)$

$\Omega := F^+ \wedge(A)$

$\Omega \cong B^A - \{\text{top}^A\}$

and

minimum binary reconstruction dimension of $\Omega = 3$.

From one finite operation, a complete language emerges. From that language, a meet appears. From that meet, a world is freely formed.

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